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**working paper  
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HIERARCHIES AND BUREAUCRACIES

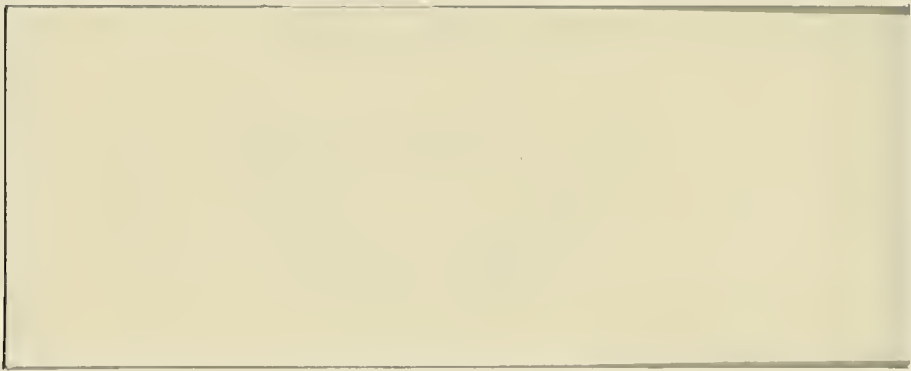
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Number 363

January 1985

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January 1985

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-ABSTRACT-

This paper considers vertical structures from a principal/agent point of view. Its central and simple theme is that coalitions may much affect the efficiency of organizations. They may considerably reduce supervisory effort as well as communication within the hierarchy. The theory developed in the paper raises two empirical questions: do we observe coalitions in hierarchies and do these coalitions distort information? How are these coalitions enforced? The paper surveys some (direct) evidence on both questions. Some implications of the theory are also derived. Outside the above mentioned X-inefficiency, the following conclusions emerge from the analysis: 1) Vertical integration, defined as a long-run relationship, may not be desirable 2) Incentive schemes may be considerably limited in a hierarchy 3) Organizations will tend to be run by impersonal rules, i.e., to become bureaucracies. As these implications seem to fit with casual observation, they can be regarded as (indirect) evidence in favor of the theory.



## 1 - Introduction

The inability or impossibility to monitor agents oneself makes delegation of supervision an ubiquitous element of economic life. There is a widespread feeling that hierarchies are hard to control and that somehow their members' incentives are insufficient. The purpose of this paper is to give some intuition about why this may be so.

Formally a hierarchy can be viewed as a series of overlapping or nested principal-agent relationships. It therefore can be analyzed using the now classic two-tier principal/agent theory.<sup>1</sup> This literature emphasizes that informational constraints and insurance purposes lead to productive inefficiency. However the central theme of this paper is that the analysis of hierarchical structures does not simply boil down to this basic inefficiency (possibly compounded by the number of relationships). Going from the simple two-level principal-agent structure to more complex ones introduces the possibility of coalitions. And coalitions may affect the efficiency of organization much, as we shall see.

I analyze a simple hierarchy, which has three tiers: top ("principal"), middle ("supervisor") and bottom ("agent") (section 3). The agent is the only productive level of the hierarchy. The supervisor's role only consists in obtaining information about the agent's activity that the upper level does not possess. The conclusion discusses the case of a productive intermediate level.

For the sake of the model, I distinguish between two types of information within an economic structure. The first kind I call

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<sup>1</sup> See, e.g., Ross (1973), Mirrlees (1975), Shavell (1979), Holmstrom (1979) and Grossman-Hart (1983).

primitive information. This is what parties observe due to their function within the structure. The supervisor may observe the agents's effort or a variable correlated with it. The principal may observe the outcome, etc... The second kind of information is communicative information. It corresponds to reporting of primitive information by a member to other members. For example the supervisor may report his appraisal of the agent's effort to the principal. Note that communicative information can only be told apart from the primitive one if there is a possibility of misrepresentation. In this paper I consider primitive information as exogenous. In particular reorganizations to modify functions within the structure are not studied.<sup>2</sup> Communicative information on the other hand is fully endogenous.

The reward structure is divided into two parts: the first part is overt ("formal") and can be observed and monitored by all the members of the structure. More precisely in an overt reward structure all parties concerned know the contracts signed between the different parties, and therefore can condition their own contracts on these contracts. The second part is called the covert reward structure. The corresponding reward flows are called "hidden transfers". The covert reward structure can not be observed, or at least can not be conditioned upon by all the concerned parties. For example transfers between agents and supervisors can not be fully monitored by the upper levels of the hierarchy. Or the contract between a contractor and a subcontractor is signed after that between, e.g., a government agency and a

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<sup>2</sup>Primitive information could also be modified by a choice of supervision effort. See section 9.

subcontractor, so that it has not been conditioned upon in the main contract (although it may have been anticipated).

After giving some examples of overlapping principal-agent relationships (section 2), I show that the existence of covert transfers seriously affects the transmission of information in hierarchies (sections 3 and 4). The basic and simple points made here are that covert transfers help enforcing coalitions and that coalitions do matter in hierarchical structures.

The second part of the paper is devoted to arguing that the previous conclusions are empirically relevant (section 5) and to drawing the further implications of these conclusions for organizational behavior (sections 6 through 10).

First the theoretical conclusions raise two empirical questions: do we observe coalitions in hierarchies and do these coalitions distort information? What are these covert transfers that help enforcing coalitions? Section 5 presents some direct evidence concerning these two questions.

Second the theory developed here throws some new light on old organizational issues such as vertical integration, limited rewards and bureaucratic tendencies. Section 6 argues that long-run relationships are not an unmitigated blessing because they help enforcing coalitions; this explains the emergence of short-run relationships and of such institutions as consulting firms, and independent and mobile corps of civil servants. Another implication of the theory is that the possibility of coalitions considerably restricts the set of incentive schemes that can operate successfully in a hierarchy. The third

implication of the theory is that organizations tend to be run by impersonal rules, i.e., to become bureaucracies. In particular the intermediate levels do not exercise the full discretionary power they could in principle have because of their central position in the information network. (See section 8.) As they seem to fit with casual observation, these three implications can be regarded as indirect evidence in favor of the theory.

Section 7 studies which coalitions are likely to form. Section 9 gives a brief overview of how the theory may apply to the public sector. And section 10 mentions some desirable extensions, and concludes.

## 2 - Examples of nested principal-agent relationships

In this section I give some examples of vertical structures. The structures are three-tier ones: principal/supervisor/agent. Obviously a number of vertical structures are more complex than the ones considered here. Indeed some higher order structures can be obtained simply by combining some of these examples. Also the verticality itself is a simplification, on which horizontal structures can be superimposed. For example the supervisor may monitor several agents. A number of insights can nevertheless be extracted from the simplest structure. Here is a list of examples:

- 1) Manager/foreman/worker
- 2) Shareholder/manager/worker
- 3) Government/department of defense/defense contractor
- 4) Government agency/contractor/subcontractor
- 5) Firm or bank/auditor/taken over firm (or investor/broker/firm)
- 6) Brass/colonel/regiment
- 7) Voter/government or representative/public or regulated firm
- 8) Economics profession/Ph.D. adviser/Ph.D. student



9) Restaurant owner/Maitre d'/waiter.

In all these examples the agent has a productive role. In most of them the intermediate level's main function (but not the only one) is to supervise the agent. It has better information than the principal about the agent's effort and work quality or the technological possibilities the latter faces. The presence of the intermediate level lessens the informational problems. The purpose of this paper is to study to what extent it does so.

These examples also illustrate the different formal (overt) reward structures. In a centralized reward structure, the principal rewards both the agent and the supervisor. For instance there is essentially no monetary transfer between a foreman and a worker. In a decentralized reward structure, the principal rewards the supervisor, who in turn rewards the agent. For instance a contractor may directly reward a subcontractor.

Lastly in all these examples there is scope for misrepresentation. In particular the intermediate level can cover the agent. Its observational superiority may allow him to overreport the agent's effort. And his superior expertise may allow him to voluntarily overestimate the quality of the agent's output or to underestimate the set of opportunities the agent faced.

### 3 - The set-up

For expositional convenience, the model and the arguments are developed somewhat informally. They are studied in more detail in the Appendix.

For simplicity, I consider a three-tier relationship:  
principal (level 3) / supervisor (level 2) / agent (level 1).

The agent is the only productive unit in the hierarchy. He takes some unobservable action, called "effort". His utility depends (negatively) on the level of effort and (positively) on his income. He is income risk averse.

All the parties observe an "outcome". This outcome is a random and increasing function (in the sense of first-order stochastic dominance) of the effort picked by the agent. It does not need to be the final payoff to the principal. It simply stands for all final commonly observed characteristics the rewards can be made contingent on. The principal's (expected) utility depends on the outcome and on his income. For simplicity we assume that the principal is income risk-neutral.

The supervisor observes some "primitive information" as well, which is not observed by the principal. This information gives the supervisor statistical knowledge about the agent's effort, either directly, or indirectly through information on the final payoff which is finer than the commonly observed outcome. On the basis of this primitive information, the supervisor makes a "report" to the principal. Like the outcome, the report is observed by all levels of the hierarchy. The supervisor's utility depends on his income only. Thus the supervisory effort level is given; its choice is briefly considered in section 10. Lastly the supervisor is risk-averse.

The principal hires a supervisor and a worker. The latter have reservation utilities, which represent what they could get in the market-place. There is competitive supply of supervisors and workers.

Finally there are reward flows between the different levels.

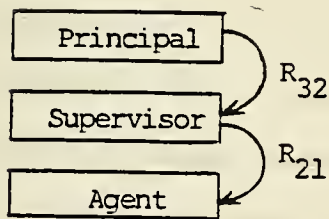
$R_{ij}$  denotes the reward from  $i$  to  $j$ .

We will say that a reward structure  $\{R_{ij}\}$  is overt if

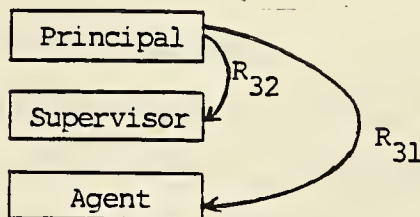
- 1) all rewards depend only on the common information, i.e., on the outcome and on the supervisor's report.
- 2) contracts are signed simultaneously; i.e, a contract between  $i$  and  $j$  is signed knowing the contract between  $j$  and  $k$  (for all  $i, j, k$ ).

The reward structure is complete if bilateral contracts between all agents are signed. A reward structure is sufficient if for any set of complete reward functions, one can find reward functions in this restricted structure such that for all outcomes and remarks, the parties' incomes are the same as in the complete reward structure (i.e., the structures are incentive equivalent).

For instance, two familiar reward structures are:



and



the decentralized reward structure : the principal rewards the supervisor, who rewards the agent,

the centralized reward structure : the principal rewards both the supervisor and the agent.

Figure 1

A simple spanning argument shows that these two structures are sufficient. This means that the principal can obtain the same utility with a decentralized as with a centralized reward structure as

long as he monitors the transfers between the supervisor and the agent (the structure is overt).

Let us give an example, which we will use as an illustration in the following. The agent (a worker, say) makes pieces. These can be good or faulty. Because of delays in observation and/or moral hazard from the principal's point of view<sup>3</sup>, the rewards cannot be made contingent on true quality, but only on delivery (so the outcome variable is trivial). The supervisor (a production engineer, say) takes a fixed size sample of the pieces made by the worker. He thus obtains an estimate of the number of faulty pieces (primitive information). He then makes a report to the principal. Of course this report needs not be honest. For example the supervisor can forge evidence to understate the number of faulty pieces. The reader can construct many other such examples for the hierarchies given in the previous section.

Let us now show that the principal can easily obtain the supervisor's information in an overt reward structure. To this purpose it suffices to give the supervisor a constant income, i.e., independent of the outcome and the report. The latter has then no incentive to lie; furthermore his expected income can be chosen to be the lowest one consistent with his participation in the hierarchy, since he is risk-averse and he gets full insurance. Given this the principal can sign with the agent the optimal principal/agent contract corresponding to the situation in which both the outcome and the supervisor's information are common knowledge. In other words the hierarchy boils down to a two-tier relationship in which the principal has the same information set as if

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<sup>3</sup>The principal (or his customers) may either deteriorate the output or delay the reward by claiming he has not observed the true quality yet.

he were a supervisor as well. To keep the problem non trivial, we will assume that the refinement in information makes the hiring of an honest supervisor worth it; i.e., the supervisor's reservation wage does not exceed the value of his information.

#### 4 - The effect of covert rewards

a) To give some first intuition I release requirement 2) in the definition of an overt reward structure. I assume that the reward structure is decentralized; that the supervisor offers a "subcontract" to the agent, which is signed after the "main contract" (between levels 2 and 3); and that the main contract does not put any restraint on the subcontract (one can think of a contract between a government agency (or a firm) and a contractor, in which the contractor is free to choose and make arrangements with a subcontractor). The question I ask is whether in spite of the decentralized structure the principal would not be better off putting restraints on the subcontract.

To show the effect of sequentiality, let us consider the previous example of a supervisor sampling for faulty pieces (one can now think of the supervisor as being a contractor and the agent as a subcontractor). As before, the principal does not observe anything but delivery. We will also assume that the supervisor can always under-report.

It is easy to see that there is no point making the main contract contingent on the supervisor's report - see the Appendix for a formal argument. The idea is the following. Were the reward structure centralized, the principal would like to reduce his reward to the agent with the observed number of faulty pieces in the sample. This policy

would encourage the agent to work harder. With a decentralized reward structure, he can only reward the supervisor less when the latter reports a high number of faulty pieces, and hope that the supervisor will transmit this penalty to the agent. He can make sure that this is indeed the case in an overt reward structure. But with sequential contracts, the supervisor and the agent are better off signing a subcontract that induces the supervisor to maximize his reward from the principal over the set of possible reports, i.e, to underreport. The reason is that they can always split the surplus (to do so it suffices that the supervisor rewards the agent according to the reward he receives from the principal, with a marginal reward between zero and one).

Note that, in this extreme example, we switch from a situation in which the principal can obtain all the information at little cost (the supervisor's reservation wage) to one in which no information can be obtained whatever the cost. With covert transfers, the supervisor is completely useless, so that the principal would not even hire one. As we have assumed that the information brought by an honest supervisor is valuable enough to justify his participation in the hierarchy, we have shown that the principal loses when the contracts are signed sequentially rather than simultaneously. So the timing of

contracts matters.<sup>4</sup>

Remark: the desirability of simultaneous contracts is a general property. The other property obtained in the above example - the uselessness of supervisors with sequential contracts - certainly is not. If a non trivial "outcome variable" correlated with the true "quality" can be observed, the principal can give the supervisor a reward that depends on this outcome, and thus induce the latter to "put the screws" on the agent.<sup>5</sup>

b) Let us now consider a sufficient hierarchical reward structure, either decentralized or centralized. But let us assume that there also exists a parallel or covert reward structure,  $T_{21}$ , between the supervisor and the agent. This reward structure can not be observed by the principal; or at least the corresponding transfers, which we call hidden transfers, can not be used in court as evidence of the existence of a coalition. We will later on give examples of such transfers.

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<sup>4</sup>This is some evidence that principals indeed put or would like to put some restraints on subcontracts. For instance a report of the U.S House of Representatives states that "procurement regulations (for government programs) seek to strike a balance between no interference with the prime contractor responsibility and reasonable assurance that the government is receiving the greatest practicable return for its expenditures". Actually "contractors have seldom been given a free hand in making subcontracting decisions" (Peck-Scherer (1964) p. 399-400). Several authors have also argued that when negotiating a contract the Department of Defense should be required to follow certain rules (Williamson (1967)) on "task partitioning", Scherer (1964) on "multidimensional contracts". Of course it is hard to know whether such restraints are not simply designed to induce a higher supervisory effort.

<sup>5</sup>To convince him/herself that the principal may want to hire a supervisor, the reader can consider the case of 1) a risk neutral supervisor b) an observed final payoff and c) an effort observed by the supervisor.

These hidden transfers can most conveniently be formalized as being monetary, although, as argued below, they will most often be non-monetary in practice.

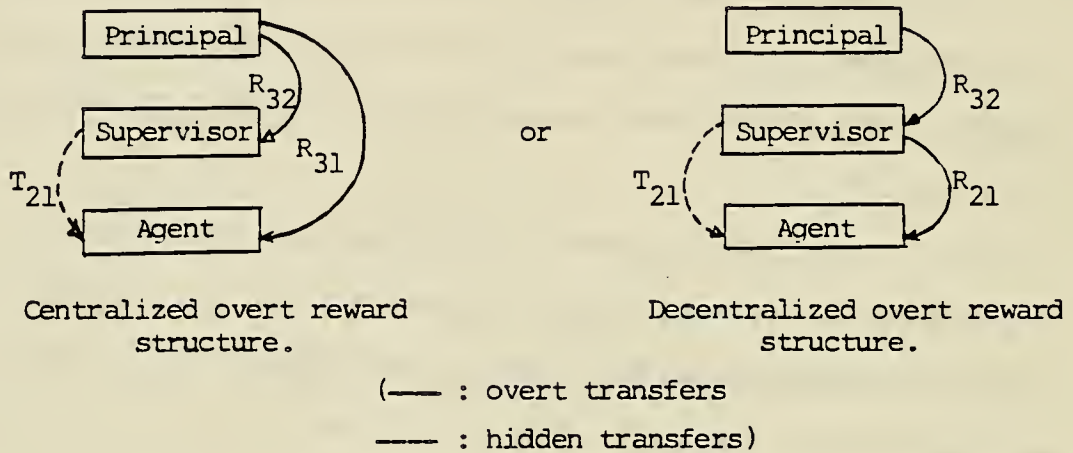


Figure 2

Since sequentiality is but a form of non observability, the following fact should not be surprising: the centralized and decentralized reward structures with hidden transfers between the supervisor and the agent are both equivalent to the sequential reward structure - for a formal demonstration, see the Appendix. The idea is that, in the decentralized reward structure, the supervisor and the agent can always untie the incentives created by the covert reward structure (only  $\{R_{21}+T_{21}\}$  matters); and furthermore that the decentralized and centralized reward structures are equivalent even where there exist hidden transfers.



So the conclusions are the same as for sequential contracts. In particular the hidden transfers considerably restrict the actual transmission of information from the supervisor to the principal.

Remark: There is one case in which sequential contracts or hidden transfers do not entail a loss for the principal. Assume -- that the outcome is a monetary one and that it is a sufficient statistics for the principal's income<sup>6</sup> and -- that the supervisor is (income) risk-neutral. We know that in an overt reward structure, the supervisor could bear all the risk (the principal would just have a fixed income). The three-tier relationship would then boil down to a classic principal/agent relationship between the supervisor and the agent. And we know that there is no room for a coalition in a two-tier relationship. This extreme case is related to Alchian-Demsetz (1972)'s idea of a monitor as a "residual claimant" - i.e., owning a title to the net earnings of the partnership. In most of the examples given below, the supervisor certainly is not income risk-neutral, so coalitions can (and do) arise.

#### 5 - Evidence on the hidden transfers hypothesis

The theory developed above has at this stage two important implications:

- i) coalitions in hierarchies may lead to important losses in the value of information flows within the hierarchy.
- ii) To form, coalitions require the existence of covert transfers, i.e., transfers that can not be accounted for in a global (overt) contract.

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<sup>6</sup>This rules out outcomes that are not readily observable, in which case the effort helps predict the principal's eventual utility.

These implications raise two empirical queries:

- i) do we observe coalitions in hierarchies, and do these coalitions distort information?
- ii) How are these coalitions enforced? In other words, what are these covert transfers predicted by the theory?

Let us try to give some evidence on both matters.

i) Casual empiricism suggests that obtaining information from intermediate levels of a hierarchy is not easy. This difficulty has been documented by both sociologists and economists:

- The French sociologist Crozier (1963) in his studies of the "Agence Comptable Parisienne" and of the French tobacco monopoly (SEITA) showed that it is very hard to obtain information from foremen about their shops. They most of the time side up with employees (e.g., p.51-52, 56). Similarly the technical engineer protects his maintenance workers' privileges (p. 153). According to Crozier there are a lot of cases in which common sense and even general interest direct the controller to falsify his information to allow the monitored group to obtain sufficient results (p.280); he is not in a position that allows him to give trustworthy information (p. 51). Crozier even talks about "clans and groups of members of different categories" (p. 264; see also Selznick (1949)'s idea that expertise tends to create a cast spirit and temptations of collusion with groups that depend on that expertise).
- The Department of Defense usually sides up with contractors when reporting to the Government or Congress (Williamson (1967), p. 233). Similarly a government may give a favorable image of public firms. Or

regulatory authorities may end up being overly sympathetic to the industry position (theory of regulatory capture).

- A Ph.D. advisor often has a tendency to push his student on the job market.
- An audit may side with the firm when estimating its cost (Schmalensee (1980)).
- A colonel may cover his regiment when reporting to the brass.
- A teacher will usually defend his class in front of the school principal.

Remark: Logically, communicative information, if it is biased, ought also to be limited. Indeed there is sometimes not much emphasis on having the intermediate level report his primitive information. Except in exceptional cases the foreman is not asked to estimate his workers' participation. A contractor will hardly ask a subcontractor about the latter's staff's effort, etc. In the same spirit, the mere observation of some collusive behaviors understates the real impact of potential coalitions on hierarchical organizations. For, as we shall see in sections 6 and 8, the latter take into account and try to restrict the possibility of collusion when they design their incentive structure.

ii) For the supervisors to have such incentives to cover up the agents' actions, there must exist covert (secondary) reward structures between the supervisors and the agents. In the previous section, I formalized the hidden transfers as being monetary. This was just for expositional convenience. Indeed in most situations I have in mind the transfer is non-monetary. The reason why it often must be so is easily understood. A monetary transfer may be observed by the principal and be used as

evidence of the existence of a coalition. Simply consider what happens or would happen if it is learned that a contractor has bribed a government official or that a Ph.D. student has given money to his advisor. Non-monetary transfers are not as conspicuous; or at least they are harder to use as evidence of the existence of a coalition. Let us give examples of such transfers.

- In a workshop workers can do a number of favors for their foreman. These can include refraining from doing unrest, going on strike, leapfrogging for complaints, etc. (and similarly for a regiment toward its colonel). Indeed according to Crozier ((1963), p. 56), the foreman, by defending his workers, obtains a better climate within his shop and is more likely to avoid trouble. Also when facing difficulties employees reject the responsibility not on their supervisors but on higher levels of the hierarchy (p. 52). Other non-monetary transfers include mutual affection and respect, as emphasized by the Human Relations School (see, e.g., Etzioni (1964), p. 34).

- Defense contractors give jobs to civil servants they have dealt with. They also often take responsibility for the failure of government personnel and avoid strong dissent against government decisions they consider incorrect (Scherer (1964), p.100).

- Public firms may reward a government that has been complaisant with votes and the absence of strikes.

- In some countries it is customary for a Ph.D. student to do research or write papers for his/her advisor.

Note that in some cases the "hidden transfers" can actually be observed by the principal but the latter can hardly use this observation as there is some probability that the transfer is justified. In other words the

principal is unable to show that the transfer is the outcome of a coalition against him. For example the defense contractor can always argue that he hires the civil servant because of the latter's great talent.

Most of the time these hidden transfers result from implicit (rather than explicit) contracts. For the reason expositied above they are not legally enforced. A widespread enforcement mechanism, that we will emphasize later on, has to do with the repetition of the supervisor/agent relationship.<sup>7</sup> A sort of "sense of honor", the fear to hurt someone one is directly facing, or social customs are important for short-run relationships.

We have discussed hidden transfers from the agent to the supervisor. Very similar things would be said about hidden transfers from the supervisor to the agent in the framework of an implicit contract: grades, promotion, enforcement of contracting terms, on-the-job pressure, renewal of contracts, etc. For example, according to Scherer ((1964), p. 73) there are lots of cases "in which after turning in a plainly unsatisfactory job a company has received a very desirable new program award".

We now turn to the study of the consequences of a covert reward structure.

## 6 - Vertical integration

Most of the literature on vertical structures has defined

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<sup>7</sup>Rational models of reputation have been built by Kreps, Milgrom, Roberts and Wilson (1982). They have shown how cooperation can emerge in finitely repeated games of incomplete information.

vertical integration as a long-run relationship.<sup>8</sup> Long-run relationships are believed to improve primitive information and to reduce incentive problems.

For example Williamson (1975) and Klein et. al. (1978) have emphasized the use of vertical integration when dealing with the accumulation of specific assets.<sup>9</sup> The idea is that long-run contracts help reducing opportunistic behavior associated with renegotiation.

A somewhat different argument in favor of long-term contracts has been given by the repeated moral-hazard literature (see, e.g., Radner (1981), Roberts (1983), Rogerson (1982), Rubinstein (1979)). The idea here is that repetition provides better statistical (primitive) information, and that in a long-run contract this improvement in information alleviates the moral hazard problem.

A major puzzle of the existing theory is that it implies that vertical integration is always desirable. The theory developed in this paper suggests that the longer a long-run relationship, the easier the enforcement of implicit contracts in a coalition. So the transmission of information may be more restricted (distorted) in integrated structures than in non-integrated ones.

The theory predicts that organizations may want to keep their members' relationships relatively short. Indeed a number of large

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<sup>8</sup>For an alternative and interesting definition based on ownership and acceptance of authority, see Coase (1937) and Grossman-Hart (1984).

<sup>9</sup>"Vertical integration is examined as a means of economizing on the costs of avoiding risks of appropriation of quasi-rents in specialized assets by opportunistic individuals" (Klein-Crawford-Alchian, p. 299). For short-term (renegotiated) contracts, see Tirole (1984).

organizations give their members (especially at the managerial and supervisory levels) incentives to switch jobs within the organization.<sup>10</sup> Sometimes they even require it. In France one of the functions of the "Grands Corps" of civil servants is to provide decision makers and analysts who are mobile and fairly independent of pressures that come from inside the organizations they are working with (because of their job-and-wage security as well as their mobility).

Another piece of evidence for the outcome predicted by the theory is the use of consulting firms to collect information. The latter are expensive and in many cases are limited in their access to primitive information. However their members have a short-run relationship with each firm they are working for and therefore are almost "(hidden) transfer-free". In a similar spirit Scherer (1964) suggested the use of an independent Program Evaluation Board to access defense programs: "Serious problems of bias and lack of comparability are likely to arise when performance judgements are made by persons deeply involved in the programs" (p. 329).

As a last example, let us notice that the advantage of an anonymous reviewing process for a journal is that the referee/author relationship amounts to a one-shot relationship.

#### 7 - Who colludes with whom?

I emphasized the role of a long-run relationship between the agent and the supervisor. There may also be a long-run relationship

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<sup>10</sup> Monotony and the lack of further on-the-job learning may be motives to change jobs; but to some extent they are internalized by the member and do not require special incentives.

between the supervisor and the principal. This may somewhat reduce the incentive to underreport. For example a university professor has a long-run relationship with the profession, and therefore has some incentive not to recommend all his students too warmly. Let me argue that in a number of interesting cases the long-run relationship between the supervisor and the principal is less relevant than the one between the supervisor and the agent.

First the agent knows the supervisor's primitive information, or at least his own effort. Therefore the agent is in a much better position than the principal to monitor an implicit contract with the supervisor. The principal has a hard time knowing whether the supervisor sides with him (take the production-engineer-sampling-for-faulty-pieces example). The relationship between the supervisor and the principal must then be very long for the latter to acquire enough statistical information about the supervisor's loyalty.

This link between the degree of asymmetric information and the enforcement of coalitions has some relevance for the theory of public firms. One of the goals of the government or the politicians is to obtain votes from the consumers (principal) and from public firms' employees (agents). Political supervisors may favor public firms over the general interest, as the consumers usually have extremely poor information about the firms' technological possibilities (see section 9).

The second argument against the relevance of such a counterbalancing power is that higher levels of a hierarchy are often more mobile than lower ones. Therefore the supervisor will tend to collude with the agent, with whom he has a longer relationship.

At this stage I ought to make two important remarks:



Remark 1. The fact that the supervisor and the agent can collude does not mean that they enjoy a rent in the organization. A rational principal anticipates the formation of the coalition and puts the lower tiers at their reservation utilities.

Remark 2. I certainly do not mean to imply that collusion can only occur at the bottom of a hierarchy. The theory developed above and its consequences also apply to coalitions between the principal and the supervisor. Examples of such potential upper-tier collusions are given by the police/justice system as well as the hierarchy in a conscription army. In such structures the agent (convict, conscript) has a shorter-run relationship with the rest of the hierarchy than the other tiers with each other. The necessity of imposing rules emphasized in the next section holds equally well.

## 8 - Summary and further implications

We have derived the following conclusions from the hidden transfers hypothesis:

i) X-inefficiency. Communicative information is limited. As a consequence the agent faces low incentives and does not expend much effort.

ii) Leapfrogging of the supervisor. The restrictions in transmitted information give the principal a strong incentive to be supervisor at the same time if he is able to do so. This effect in general calls for less relying on the intermediate levels for information and for more direct control, either personally or through independent bodies:

independent auditors, consulting firms, mobile civil servants. (Note however that the latter solution is not fool-proof. All countries know

that having a special police corps checking the police does not solve everything: "Who will take care of the caretakers?").

iii) Control of transfers. The principal may also have an incentive to put restraints on hidden transfers. He (or the law) can forbid monetary transfers between the supervisor and the agent.<sup>11</sup> Non monetary transfers are harder to curb. Forcing the supervisor to switch agents relatively often is a step toward this goal. More generally long-run relationships may have undesirable properties.<sup>12</sup>

Two further implications of our analysis ought to be noted:

iv) Limited rewards. Economists have long been recognized that incentive schemes are much restricted relative to the theoretical possibilities.<sup>13</sup> One good explanation (given by the principal-agent literature) is that agents are very risk averse. I here offer an alternative reason for this fact. The theory suggests that reward schemes that are "coalition incentive compatible" will tend to be chosen. Therefore the overt rewards from a supervisor to agents are often restricted to the allocation of a fixed size reward between different agents supervised by the supervisor. Promotions and grades (to the extent that they are compared to the average of grades given by

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<sup>11</sup>Although we treated the centralized and decentralized reward structures as equivalent, the centralized structure can be in practice more efficient to curb hidden monetary transfers.

<sup>12</sup>Similarly a firm or government agency may want to put restrictions on the type of contracts its contractor can sign with a subcontractor.

<sup>13</sup>Say, compared to the residual claim to the agent's output.

a supervisor) are the simplest such incentive schemes.<sup>14</sup> (Note however that even the allocation of a fixed size reward may not be coalition incentive compatible, if collusion between the supervisor and subsets of agents ("favoritism") cannot be avoided.)

v) Bureaucracies. To the extent that little information can move upwards, organizations tend to become bureaucracies, i.e., to be run by impersonal rules. The role of rules has been emphasized by, among others, Weber (1947), Crozier (1963), and Arrow (1974) ("impersonal authority"). To my mind the main feature of rules is that they leave no discretionary power to their enforcer, who is supposed to follow the letter. Consequently rules suppress face-to-face relationships (Crozier (1963)) and tensions (Gouldner (1954)).<sup>15</sup>

For example a foreman may not be entitled to allow a worker to be absent even if he, but not the higher levels of the hierarchy, has the information relevant to this decision. More generally foremen have almost no initiative as to personnel management and organization (Crozier (1963), pp. 51-52, 56, 176, 238). As another piece of casual evidence: how many times do we hear when dealing with an employee of an administration: "I know that in your case the rule ought not apply, but I have got to abide by it"? The point is that rules are supposed to be absolute. Therefore it is relatively easy to make sure that they are applied.

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<sup>14</sup>Sudipto Batthacharya gave me a related reason why rank-order tournaments (Green-Stokey (1983), Lazear-Rosen (1981), Nalebuff-Stiglitz (1983), Mookherjee (1983)) and more generally fixed size rewards may be preferred to more complex schemes even if the relationship is only two-tier. The idea is that the outcome may not be observable by a third party (legal enforcer), who then has to rely on the principal-supervisor's statement.

<sup>15</sup>Gouldner also argues that new tensions and the need for more supervision are created by the lack of motivation.

We emphasized the role of rules as a restriction on the supervisor's discretion in order to protect the principal. In some cases rules can also protect the agent. One can, for instance, think of the possibility of upper-tier coalitions in law enforcement or in the army (see section 7).<sup>16</sup>

9. An example: agency theory and efficiency in private and public organizations

In our model the supervisor receives primitive information and reports to the principal. Several authors (Calvo-Wellisz (1978), (1979), Mirrlees (1975), Williamson (1967)) assume that the intermediate level(s) have a choice of supervisory effort (for example the probability of discovering that an agent shirks decreases with the supervisor's effort). They derive some interesting results about the optimal size of a vertical structure and about wage differentials, analyzing the level of primitive information in an overt reward structure. On the other hand there is no choice of communicative

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<sup>16</sup>Crozier has also argued that rules are used to protect workers. The possibility of upper-tier coalitions is not the only reason why workers ought to be protected from the supervisor's discretionary power. Consider the firing problem. It is well-known that it is fairly difficult to dismiss a worker in a hierarchy. However, it may be very reasonable not to let the supervisor fire a worker (i.e., not to follow his recommendations to do so) even if the supervisor has all the relevant information about the worker's effort. The point is the following: like in this paper the supervisor's risk-aversion (or the unobservability of the final payoff) prevents him from being the residual claimant for the worker's output. So the supervisor has an incentive to trade-off productive efficiency against other (private) goals. For instance he can fire a worker simply because of personal antipathy. Or, as his relationship with the worker is not one-shot (if the latter is not fired) and as there usually is a cost to the worker to being dismissed, the supervisor can use his firing power to blackmail the worker (Think of sexual harassment.)

information: the intermediate level(s) report their primitive information honestly. And (more importantly) there is no possibility of coalitions. So their approach is complementary to the one developed in this paper.

It seems worth comparing the implications of these approaches for a wide range of applications. Such an exercise is clearly out of the scope of the paper. As an example, let us briefly analyze what economic theory -- through principal/agent models -- has to say about the relative productive efficiencies of the public and private sectors. Doing so we will ignore some important aspects of the problem in order to highlight a few ideas. Also the conclusions are tentative and ought to be based on more thorough empirical work. Their goal is mainly to show that agency theory has potentially important implications for the issue.

In a world without informational asymmetries, public organization is superior to a private one, since it can eliminate the distortions associated with the private interest (monopoly power, externalities, etc.). Casual observation, however, shows that this view must be tempered, as public firms often look harder to control than their private counterparts. If public firms indeed have a systematic bias towards X-inefficiency (which will be the hypothesis), economic theory ought to provide an adequate framework to exhibit and study this bias. Let us argue that agency theory is able to explain at least some of this bias.

A first possibility consistent with the hypothesis is that public firms' supervisors are not able to exert the same control as their private counterparts. This arises if somehow the information structure in the supervisor/firm relationship is finer for the private

sector (as shown by Holmström (1979) and Shavell (1979), a better information structure implies that the supervisor's goals are more effectively implemented). However it is not clear that government officials in charge of a given firm have inherently less information than its shareholders would have, were the firm private. So it seems difficult to derive strong normative conclusions on the relative merits of the two systems based on this supervisor/firm two-tier model.<sup>17</sup>

Let us now explore the possibility that the public supervisors' objectives do not internalize the social goals. This view implicitly assumes a more complex structure than the traditional principal/agent one. We continue adopting the extremely simplified view that the firm is a unique agent, but we refine the description of the supervision structure. We here borrow unrestrainedly from the insights of Downs (1967), Niskanen (1971), Olson (1978) and Tullock (1965) among others. For the sake of the argument let us represent the control structure of a public firm as having one more layer than its private counterpart.<sup>18</sup> The idea is that the real shareholders of a public firm

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<sup>17</sup>We can, however obtain some positive explanation of why public firms sometimes look more inefficient than private ones. The point is that public firms often operate as monopolies and produce non-marketed goods. Niskanen (1971) and Downs (1965) have argued that these characteristics render the control of firms harder, as no information can be obtained from competition (such arguments have been recently formalized by Hart (1983), and by the literature on tournaments). So, coming back to the basic principal-agent model, this means that the shareholders of such firms have less information, and therefore less control on their firms. From this, we ought to conclude that the public sector may be inefficient on average, but not per se. Because nationalizations often occur precisely because of increasing returns and public good aspects, the public sector simply represents a biased sample in terms of controllability.

<sup>18</sup>The notion of layer is of course contingent on the asymmetries of information. The purpose of the two-or-three-layer oversimplification is to point out what may be the main asymmetries of information in a hierarchy.

are the "consumers", and that these consumers delegate their supervisory power to representatives or government agencies:

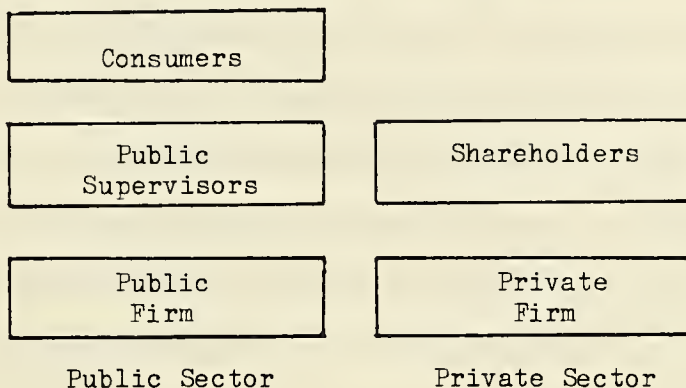


Figure 3

We will assume that, for a given supervisory effort, the public supervisors obtain the same information about the firm as the shareholders would, were the firm private.

Let us start with the view that a hierarchy is a simple compound principal/agent relationship (coalitions are not an issue.) This approach tells us that more information and control are lost when an extra layer is introduced. This loss is higher, the more limited the incentives faced by the public supervisors. The supervisors choose a lower level of supervision if they are not the residual claimants for the social objective function (in the sense of Alchian-Demsetz (1972)).

The firm can then indulge itself in more X-inefficiency. In order to obtain a legitimate validation of the original hypothesis, one must first argue that public supervisors do not internalize social objectives fully. Agency theory tells us that for supervisors, to be residual

claimants, must either be risk-neutral or be tightly monitored by the consumers. A plausible case can be made that both conditions are unrealistic; in particular consumers miss important information about the firm and the supervisor's activities, and, because of the public good problem, may not be willing to acquire it (as stressed in particular by Olson (1978)). Second, one must argue that the absence of residual claimancy -- a likely possibility -- does lead to a lower supervisory effort in the public sector, since this is the channel through which X-inefficiency is higher in public firms. In particular, effort supply must be sufficiently elastic. On the basis of fairly casual evidence (mainly for the French case), it is not clear to me that public supervisors work less hard or obtain less information about their firms than their private counterparts (shareholders).<sup>19</sup>

Let us now examine the possibility that the public supervisors may form a coalition with the firms they are supposed to control. If they do so, they will indirectly act in the interest of the firms rather than of the consumers. As shown by sections 4 and 7, to defend this view, we must explain how the coalition between the public supervisors and the public firms can form (i.e., describe the covert transfers) and why this particular coalition forms. The mechanisms of bilateral exchange are numerous. As already mentioned, the consumers' information is usually poor, which gives some leeway to the public supervisors. These can tolerate more slack, perks, defend job stability (they may not be able to pay higher wages, as these can more easily be

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<sup>19</sup>The inelasticity of effort may result from tastes, or carrier objectives, etc.



monitored by the consumers). What can public firms offer to their supervisors? Remember that the latter value votes (directly for politicians, indirectly for civil servants, whose promotions and rewards are determined by politicians.) Public firms' employees can reward the supervisors by their votes. Similarly, they can influence their supervisors' public image by refraining from going on strike, or arguing against them. Lastly, public firms can later provide jobs to their current supervisors. All these transfers are covert, in the sense that they cannot be perfectly controlled by the consumers. (The law, however, tries to curb transfers such as political contributions from utilities or jobs for the regulators in the regulated firms -- which one would expect, as mentioned in section 8.) Second we must argue that the public supervisor/public firm coalition is a natural one. In section 7 we have quoted two reasons why supervisors may be more likely to collude with the agent. The second reason -- that supervisors have a longer relationship with the agent than with the principal -- does not seem to apply here. To the contrary, the first reason -- that the information structure is such that it is easier for the agent than for the principal to monitor cooperation with the supervisor -- seems relevant; this again rests on the idea that the general public has much less information than its representatives. So the ingredients exist to ground a differential X-inefficiency of the public sector on the possibility of collusive behavior in hierarchies. Similarly there is hope that more complete theoretical and empirical work will result in agency foundations for the "capture theory of regulation". The relevance of the theory will then be easier to assess.

## 10. Conclusion

This paper describes the organization as a network of overlapping principal/agent relationships, and studies how incentives can trickle down the hierarchy. This line of attack supplies a formal framework that fits with old observations on bureaucratic behavior and limited rewards. It also predicts that vertical integration is not the unmitigated blessing implied by the more traditional principal/agent theory. And finally it indicates which levels of the hierarchy are likely to collude.

We should mention that the analysis carries over to some slightly different vertical structures (such as IRS/homeowner/moonlighting gardener; or train company/ticket inspector/passenger) or to some multiagent structures (a convict or car driver with a good file may confess for another; an AAA member may ask the association to tow a friend's car).

As mentioned in section 9, an interesting and realistic extension of the model would give the intermediate level a more active role, either in supervision or in production. It would seem for instance that the choice of a supervision level would increase the tendency to "cover-up" the agent if the supervisor can commit himself to a level of supervision before the agent chooses his effort: reporting an agent's mistake/shirking then amounts to acknowledging that supervision was insufficient (colonel/regiment example). This effect would disappear if the supervisor's effort is chosen after the agent's (absence of commitment)<sup>20</sup>. These open questions clearly deserve further study.

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<sup>20</sup>In general the analysis will be related to Holmstrom (1982)'s paper on incentives in syndicates.

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Appendix

The purpose of this Appendix is to develop the arguments in the text with more rigor. For expositional simplicity, transfers will be monetary ones. Besides being relevant in some cases, they are a proxy for non-monetary ones in other cases. First, in some relationships, they represent the monetary equivalents of non-monetary transfers such as respect, mutual affection, etc. Second, in repeated relationships, they are a shortcut for the benefits of building a reputation with the party one is colluding with. Such benefits could easily be formalized using the recent literature on reputation (see footnote 7); but the analysis would become lengthier, without much gain for the points being made here.

1) The model: The agent expends some effort  $e > 0$ . The outcome  $y$  is an increasing function of  $e$  and of a random variable  $\theta$ :  $y(e, \theta)$ . The prior probability distribution on  $\theta$  is common knowledge. Depending on the situation the random variable may or may not be observed by the agent before choosing the effort level. The outcome  $y$  is observed by the three levels. The supervisor also observes some primitive information  $s$  belonging to some set  $S$ .  $s$  brings information on the effort level either directly or indirectly (through information on  $\theta$ ). The principal only observes the outcome  $y$  (more generally his information could be a garbled version of the supervisor's). This requirement keeps the structure vertical by not allowing a team of supervisors with complementary informations.

A crucial element in the hierarchical structure is what the supervisor can report. In general there will be a subset of  $S$ ,  $R(s, y)$ ,

containing  $s$ , of allowable reports  $r^{21}$ . We assume that the report  $r$  is observed by all the parties.

Let us now consider the objective functions and the reward structure. Let  $R_i$  denote level  $i$ 's income. Level 1 has ex-post utility  $U_1(R_1, e)$  where  $e$  denotes his effort. Level 2's utility is  $U_2(R_2)$  (Remember that we have ruled out a choice of supervision effort). Level 3's utility is  $U_3(R_3, y)$ .  $U_3$  may actually denote an expectation as observation  $y$  may not completely describe the final payoff to the principal. We assume that levels 1 and 2 have reservation utilities  $\bar{U}_1$  and  $\bar{U}_2$ . These are the utilities they could get outside the vertical structure. They will accept belonging to the structure only if  $EU_1 > \bar{U}_1$  and  $EU_2 > \bar{U}_2$ . There is a competitive supply of supervisors (at utility  $\bar{U}_2$ ) and agents (at utility  $\bar{U}_1$ ). Lastly  $U_i$  is concave in  $R_i$ , for  $i=1,2$ , and linear in  $R_i$  for  $i=3$ .

Let  $\bar{R}_2 = U_2^{-1}(\bar{U}_2)$ . We will assume that if the principal could hire an honest supervisor, he would do so: the value of a correct information ( $r=s$ ) exceeds the cost  $\bar{R}_2$  that the principal would have to pay for the presence of the supervisor if such a supervisor existed. Otherwise the problem boils down to a two-tier organization (without the supervisor.) We denote by  $R_{ij}$  the reward flows from level  $i$  to level  $j$ ,  $i > j$ .

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<sup>21</sup>Very generally the supervisor cannot announce an  $r$  that is physically inconsistent with  $y$ .  $R(s,y)$  depends on the situation that is considered. To give an example, imagine that a production engineer takes a sample of the pieces made by a worker. If he finds that five of them are faulty, he can announce he has found two and is able to provide evidence for his claim. He may, however, not be able to announce more than five, as the worker may successfully challenge the report.

2) Sufficiency in overt reward structures. To show that any complete reward structure  $\{R_{32}, R_{31}, R_{21}\}$  is equivalent to some decentralized structure  $\{\tilde{R}_{32}, \tilde{R}_{21}\}$ , as well as to some centralized one  $\{\tilde{R}_{32}, \tilde{R}\}$ , it suffices to consider  $\tilde{R}_{32} \equiv R_{32} + R_{31}$ ,  $\tilde{R}_{21} \equiv R_{31} + R_{21}$ ; and  $\tilde{R}_{32} \equiv R_{32} - R_{21}$ ,  $\tilde{R}_{31} \equiv R_{31} + R_{21}$ . Thus we have obtained:

Fact 1: (equivalence result): In an overt reward framework, the decentralized and centralized reward structures are both sufficient.

3) Simultaneous vs. sequential contracts. I will assume that all rewards depend only on the common information  $(y,r)$ . The assumption makes sense if the subcontract is legally enforced and is, as well as the actual transfer, ex-post observed by the principal. (If the subcontract can be observed by the principal and depends on some other report  $r'$  by the supervisor, this report can be used by the principal as evidence of a coalition. For example if a contractor has tested the subcontractor's product and has found five faulty pieces in the sample, he cannot both report  $r=0$  to the principal and  $r'=5$  to the subcontractor). In the example below the measurability with respect to  $(y,r)$  actually turns out not to matter, so I will not discuss it further.

Fact 2: The timing of contracts matters.

To show this we take the extreme example developed in the text. The subcontractor's effort determines the proportion  $x$  of faulty pieces of a product, jointly with a random variable: let  $x(e,\theta) \in [0,1]$  denote this proportion. The supervisor samples and observes an estimate of  $x$ :  $s(x,\eta) \in [0,1]$ , where  $\eta$  is a random variable that represents observational noise, and  $s$  increases with  $x$ . We assume that when paying for the output



the principal does not observe anything but delivery. The principal's ex-post utility depends on  $x$  and therefore on the agent's effort. For simplicity we assume that  $R(s) = \{r \mid r \leq s\}$ , so that the supervisor can always underreport (see footnote 21).

Let us consider simultaneous contracts. The principal "chooses" contracts  $\{R_{32}(r)\}$  and  $\{R_{21}(r)\}$  (in practice he could choose the contract  $R_{32}$  and put a clause according to which the contract is valid only if the subcontract is  $R_{21}$ ). We claim that an optimal contract is the following:

- a)  $\forall r R_{32}(r) - R_{21}(r) = \bar{R}_2$  (where  $\bar{R}_2 = U_2^{-1}(\bar{U}_2)$ ).
- b)  $\{R_{21}(\cdot)\}$  is the optimal contract in the (bilateral) principal/agent relationship between the principal and the agent, where the principal observes the true sample estimate.

Under this contract level two has full insurance and obtains his reservation utility. Moreover, he has no incentive to lie<sup>22</sup>. Thus the principal obtains full information and the supervisor's expected reward is the minimal one consistent with his belonging to the structure. This result is easily generalized.

Second consider sequential contracts. Suppose that the principal chooses a contract  $R_{32}(r)$ . The best contract that the supervisor can sign with an agent is the following: let us define

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<sup>22</sup>If one wants to make sure that he strictly prefers to tell the truth, it suffices to increase the slope of  $R_{32}$  by an arbitrary small amount. This will give the supervisor an incentive to report high levels of failures. As we have assumed that  $R = \{r \mid r \leq s\}$  (the agent can challenge the supervisor for evidence), the supervisor will tell the truth (note that the optimal principal/agent contract between 3 and 1 under "full" information (i.e., knowing  $s$ ) is such that the reward decreases with  $s$ ).

$R_{32}(r(s)) \equiv \max_{r \in R(s)} \{R_{32}(r)\}$ . Next let us consider the minimal level of effort (zero, say) and the induced probability distribution on  $s$ , and therefore on  $R_{32}(r(s))$ . And consider the optimal sharing rule between levels 1 and 2 a) when the pie to share has size  $R_{32}(r(s))$  and its distribution is the one induced by the minimum level of effort and b) such that the agent's expected utility is  $\bar{U}_1$  (about sharing rules, see, e.g., Wilson (1968)). This sharing rule can be written as a transfer from 2 to 1:  $R_{21}(r)$ . As is well known for optimal sharing rules,  $R_{21}$  and  $[R_{32} - R_{21}]$  increase with  $R_{32}$ . Now it is clear that for this subcontract, the agent will play his minimal level of effort. For any realization of the random variable  $\theta$ , this will increase  $x$ , and therefore it will increase  $s$  for any  $\eta$ . This, in turn, cannot lower  $R_{32}(r(s))$ . Hence, the surplus to be distributed between levels 1 and 2 and therefore the agent's income are maximal. And similarly for the supervisor.

To summarize any given contract  $R_{32}(\cdot)$ , the best subcontract will induce a zero effort. Hence there is no point having an incentive scheme and the best the principal can do is to offer a constant reward  $R_{32} = \bar{R}_2 + \bar{R}_1$ . This result assumes that the principal hires a supervisor. But the supervisor costs  $\bar{R}_2$  and does not provide any useful information. Therefore it is even better for the principal to do without the supervisor. Even so the principal would strictly prefer the (three-tier) simultaneous contract (by assumption).

4) Hidden transfers. Assume that a hidden transfer  $T_{21}$  can be operated after the overt reward structure has been set up. Hidden transfers are formalized as unrestricted monetary ones. We assume for the moment that

these transfers depend only on the outcome  $y$  and the report  $r$ . In principle they could also depend on the true observations for instance (such an extended contract would not be legally enforceable, but, as we see earlier, much of the action has to do with implicit contracts). I discuss extended contracts in the remark below.

Fact 3: The centralized and decentralized reward structures with hidden transfers are both equivalent to the sequential contracting structure.

To show this let us consider the case of a decentralized reward structure. Let  $\{R_{32}, R_{21}\}$  denote an overt reward structure. We have to specify how the implicit contract  $T_{21}$  is chosen. For the moment let us assume that the supervisor chooses  $T_{21}$ . Given  $\{R_{32}, R_{21}\}$ , the supervisor chooses  $T_{21}$  so as to maximize  $EU_2(R_{32} - R_{21} - T_{21})$  subject to  $EU_1(R_{21} + T_{21}, e) > \bar{U}_1$  and  $e \in \arg \max EU_1(R_{21} + T_{21}, e)$ <sup>23</sup>. Clearly if  $T_{21}$  is a solution to this optimization problem,  $\tilde{R}_{21} \equiv R_{21} + T_{21}$  is a best reward structure for the supervisor in the sequential contracting process in which the principal offers  $\tilde{R}_{32} \equiv R_{32}$  to the supervisor. And conversely. Moreover for the supervisor to be willing to work, the maximum of this program must exceed  $\bar{U}_2$ . It will be equal to  $\bar{U}_2$  when the principal chooses  $R_{32}$  (or  $\tilde{R}_{32}$ ) optimally.

One may wonder whether this result does not rely on the supervisor's choosing the implicit contract. If instead there were a more even power relationship between the supervisor and the agent, the level of

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<sup>23</sup>We are here implicitly assuming that effort is chosen before the realization of the random variable  $\Theta$ . This assumption obviously is irrelevant.

initial transfers  $R_{21}$  could in principle affect bargaining. However for the principal's optimal contract, and taking the implicit contract into account, the supervisor and the agent get exactly their individual rationality level, and therefore there is no division of surplus to bargain about.

The proof for the centralized reward structure is very similar. It suffices to define sequential transfers  $\tilde{R}_{21} \equiv R_{31} + T_{21}$  and  $\tilde{R}_{32} \equiv R_{32} + R_{31}$ . Remark: we have assumed that the hidden transfer  $T_{21}$  is a function of  $y$  and  $r$  only. This assumption makes sense in the example developed in section 3, where the outcome is not observed at all by the principal ( $y$  is a constant). Indeed we have noticed there that the subcontract could w.l.o.g. be chosen measurable in  $r$ . In general some proxy for the outcome may be observed and can be used as a basis for an incentive scheme. In particular the supervisor's reward depends on  $y$ . As far as implicit contracts are doable (presumably because of the repeated character of the relationship),  $T_{21}$  can be conditioned on the true observations, assuming the agent observes it. This of course helps recovering some of the information lost in the extended reward structure. The practical relevance of this may be quite limited. In most of the examples given in section 2, the supervisors (or members of the supervision team) are fairly risk-averse, and their actual share of the risk on  $y$  is quite small.

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